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FLIGHT DYNAMICS AND CONTROL OF FLIGHT VEHICLES

An Efficient Algorithm of Data Smoothing in Real-Time Calculations

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Abstract—We propose an algorithm for real-time data smoothing due to considerable reduction and simplification of computations by employing the recursive least mean squares technique. The efficiency of algorithms is shown by an example of determining the flight airspeed and altitude based on the data of pressure sensors.

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INTRODUCTION

The tasks of signal filtering in navigation estimations using the inertial and satellite navigation systems (INS and SNS) are generally attributed to the different schemes of INS and SNS integration [1] based on the integral Kalman filter for reducing the INS inaccuracies, on the one hand, and the SNS noise, on the other hand. However, the task of preliminary smoothing of sensor signals can be also solved separately [2], for example, for providing the smooth control for actuators and mechanisms [3–5]. It is needed only to ensure the maximum simplification for computational overhead and unloading of an onboard computer for main navigation calculations. This paper deals with an efficient smoothing algorithm and its practical application.

The unmanned aerial vehicle (UAV) control calculation is based on the signals of different sensors (airspeed sensor, pressure sensor, GPS data, and other navigation sensors). Sometimes there is a need in preliminary smoothing of raw data distorted by noise. All calculations should be performed for a maximum short time.

We present, as an example, the raw data from an airspeed sensor at acceleration up to 70 km/h at zero-wind conditions (Fig. 1) and the GPS data on airspeed (Fig. 2) that have been time-triggered. The rate of data receiving from the sensors installed on an automobile to the ground station was 20 Hz and that of GPS data update was 2 Hz.

Raw sensor data should be smoothed. The computational smoothing procedure should be packed to a minimum interval of on-line control and navigation calculations.

As a rule, the Least Mean Square (LMS) algorithm that find wide application in the tasks of adaptive signal processing (filtration) in radio engineering, is most suitable for the adaptation to this purpose [6]. Among all the other algorithms, the Least Mean Square (LMS) algorithm is most suitable for the adaptation to this purpose. The LMS is simple in view of calculation complexity (number of required computations), simple for understanding (described by only few formulas), and easy in implementation.

All additional calculations on preliminary smoothing should be compacted to a minimum interval of on-line calculations and available hardware resource. We suggest reworking the idea of local approximation by reduction of computational procedure.